

DESIGN AND CALIBRATION OF THE CAROUSEL WIND TUNNEL

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In the study of planetary aeolian processes the effect of gravity is not readily modeled. Gravity appears in the equations of particle motion along with inter-particle forces but the two terms are not separable. A wind tunnel that would permit variable gravity would allow separation of the forces and aid greatly in understanding planetary aeolian processes.

Wind tunnels suffer from several shortcomings in aeolian experiments, primarily due to limitations of size. The flow Reynolds Number is a function of the distance from the tunnel entry and for most experiments a long distance is desirable to obtain a sufficiently high Reynolds Number and corresponding fully developed turbulent boundary layer.

A uniquely designed carousel wind tunnel allows for a long flow distance in a small-sized tunnel since the test section is a continuous circuit. It also allows for a variable pseudo gravity.

The carousel wind tunnel consists of two concentric drums, the space between the drums being the test section. A wind is generated by rotating the inner drum, which causes a velocity gradient in the air between the drums. This velocity is large enough to initiate movement of sand particles.

A prototype design has been built and calibrated to gain some understanding of the unique characteristics of the design and the results are presented. This prototype does not incorporate the variable pseudo gravity feature, but the design for this aspect is discussed. It is proposed to install this wind tunnel in the NASA KC135 aircraft used for zero g experiments. By comparing the velocity required to initiate saltation threshold at earth gravity, near zero gravity, and at or near 2g's we will be able to make an initial assessment of the effect of gravity on saltation threshold. It will also give us experience in working with this type of tunnel in variable gravity fields.

The experiment will be done in the following manner: A small quantity of sand of a given size will be placed in the test section. The inner drum will be brought to a speed below that required for particle threshold. The bed will be observed as the aircraft begins its maneuver to reduce the apparent gravity and the gravity force at threshold will be recorded. This experiment will be repeated at different inner drum speeds and thus a curve of gravity force vs. particle threshold speed will be obtained. When the aircraft is performing its recovery maneuver the gravity force will approach two g's. By observing the gravity level at which particle movement ceases for various inner drum speeds the relationship between particle movement and gravity force can be extended above 1 g.

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Calibration was performed in the following manner: Using a photo-tachometer to determine drum speed, the drum RPM was correlated with the output from a magnetic pickup sensor displaying a digital readout proportional to drum speed. A TSI hot wire anemometer system was then used to obtain velocity profiles between the drums at five locations between the end walls. This was done for a "large" drum and a "small" drum. The large drum is two thirds the diameter of the outer drum and the small drum, is one-half the diameter of the outer drum. Having examined the data it has been determined that the large drum is more suitable for threshold experiments, while the small drum is better for examining particle trajectories. These data are presented as the ratio of the wind speed obtained to the rim speed of the inner drum vs. the percentage of distance to the outer drum. RMS values of the velocity fluctuations were also taken at selected locations to determine the turbulence level.

Tests were performed using sand of various sizes and thresholds were determined under laboratory conditions. These will be used as a data base to compare the flight data against.

In the final version of this tunnel both the inner and outer drums will rotate. This type of tunnel would be most useful in a zero gravity environment. It will permit a psuedo-gravity effect to be induced, i.e., by rotating the outer drum the particles will be held to the surface by centrifugal force while in contact with the drum. The movement of the drums can be so coordinated that a particle could lift off and return to the surface at the same spot or any chosen location. This would allow some interesting experiments that would shed light on the orgin and development of aeolian ripples and other bedforms.